REVIEW RESOURCES

Lesson 24: Production, Quality, and Manufacturing Management

What Is the Fiscal Impact of Production and Manufacturing?

Production and manufacturing account for approximately 30 percent of the life-cycle costs for a system. This amount is three times the resources spent on all the development to this point! A great amount of money is spent during a short time period. When problems occur in manufacturing, they affect the entire acquisition process—at an exponential rate and cost. Problems during this phase are seldom resolved quickly or cheaply.

PM Production Responsibilities

The Program Manager (PM) needs to be especially aware of and avoid activities that can contribute to wasted efforts. Factors such as changing design requirements, late design releases, lack of production planning, and unstable funding can result in increased costs and production delays.

Because of the magnitude of the fiscal impact of production and manufacturing, there is a high degree of service and congressional interest in this process.

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Design Engineering and Production

DOD 5000.2-R states that:

- Producibility shall be a priority of the design effort.
- Manufacturing must be integrated into the design process in order to reduce program risk.
- Design engineering efforts shall focus on concurrent development of producible designs, capable manufacturing processes, and process controls to ensure requirements satisfaction and minimize manufacturing costs.

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The Three-Step Production and Manufacturing Integration Process

Production and manufacturing can best be integrated using a three-step process.

Step 1: Influence the Design Process

Integrate manufacturing considerations into the evolutionary requirements process, acquisition strategy development, system design, and program risk management.

Step 2: Prepare for Production

Deploy the customer's critical requirements all the way down to the manufacturing operations of the factory floor. Understand the program's strategy and funding.

Step 3: Execute the Manufacturing Plan

Early success in integration results in a smooth transition to production with known risks. The results should be uniform, defect-free products, with consistent performance and at the lowest cost.

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Basic Elements of a Manufacturing Process

Design is transformed into finished product through a process made up of five basic elements: Manpower, Measurement, Method, Machinery, and Material. The 5Ms are used to ensure the system design is capable of being produced into a uniform, defect-free, reproducible product.

Manpower

Manpower is the utilization of people. Welders working on the Seawolf submarine at General Dynamics (Electric Boat Company) required special training and certification. The certification process took 18 months to 2 years. Imagine what would happen to manpower utilization if the contract requirement started to fluctuate!

Measurement

Often overlooked are the systems needed to measure things from the raw material to the testing of the final system. These measurement systems provide for precision and accuracy in the manufacturing process. Examples of measurement include: inspection, gauges, tolerances, or Statistical Process Control (SPC).

Method

Method represents the way that raw materials are formed, shaped, and held together. Often there are many methods to accomplish the forming of a part. Both the materials and design requirements drive the selection of the methods. For example, boring a hole can be done by drilling with a bit, abrasive water jet, or laser beam. The accuracy and precision needed will usually dictate the method.

Machinery

Machinery varies in types, particularly in terms of the volume of production. Robotics and automated machines differ from those requiring a dedicated operator. For example, manufacturing a satellite involves several highly trained personnel and results in the production of one or two units per year. Contrast this output with the automated machinery used to manufacture millions of ball bearings each year.

Material

Material includes all the raw materials that are needed to produce the parts/assemblies for the system and for the production equipment itself. Materials are often dictated by the functional requirements of the system. For example, an airplane that must be capable of going supersonic speeds requires high-temperature-tolerant, lightweight, and high-strength materials.

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Producibility

Producibility is the relative ease of manufacturing an item or system. Producibility is a design accomplishment resulting from a coordinated effort by:

- Systems/design engineering
- Manufacturing/industrial engineering

This coordinated effort creates a functional hardware design that optimizes ease and economy of:

- Fabrication
- Assembly
- Inspection
- Test and acceptance

A producible design does not sacrifice desired function, performance, or quality.

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Five Top-Level Design Goals

The five top-level design goals for a producible product include the following:

Design for Ease of Fabrication

Designs that are complex to form or shape may result in excessive fabrication time. Also, complex designs often cannot be fabricated at consistent quality levels. New processes may enhance the ease of fabrication of products.

Design for Ease of Assembly

Assembly is the number-one driver of labor costs. The use of computer-based design aids may help to assess how easy a subsystem is to assemble. A balancing act exists between easing assembly and fabrication. The complexity of the fabrication may need to be increased in order to reduce the assembly time.

Design for Multiuse

When possible, the design should specify that the same part or assembly process should be used several times, even across product lines. Multiuse permits certain economies of scale and helps support the logistics aspects of the system.

Minimize Number of Parts

In addition to the cost of material and fabrication, every part has an overhead cost. By minimizing the number of parts, the overall cost of the product—including the cost to support the system—is reduced. The minimization of parts applies to both the number of total parts as well as to the number of different parts.

Maximize Number of Common Parts

Another design goal is to optimize the number of common parts. For example, designers should consider items from a qualified parts list. Common parts potentially could be produced by a large number of suppliers. The use of common parts is preferred over more intricate or complex parts. Tailored, complex parts are harder to machine, cast, or otherwise manufacture. The use of common parts also benefits logistic support.

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What Is a Quality Management Process?

A quality management process is the quality system the contractor uses to ensure:

- Customer satisfaction
- Defect-free products
- Continuous improvement

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Contractor Choice of Quality Process

DOD 5000.2-R (Paragraph 4.3.2) states:

"…The PM shall allow contractors the flexibility to define and use their preferred quality management process that meets program objectives. Third-party certification or registration of a supplier's quality system shall not be required…"

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Key Quality Activities

DOD 5000.2-R specifies that whatever system is adopted by the contractor, it shall include the following key quality activities:

- Establish Capable Processes,
- Monitor and Control Critical Product and Process Variations,
- Establish Mechanisms for Feedback of Field Product Performance,
- Implement an Effective Root-Cause Analysis and Corrective Action System, and
- Continuous Process Improvement.

Allowing contractors more control of the quality process should reduce the cost of the system and improve the overall quality of the system.

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Quality Standards and Systems

Industry and Government consider international quality assurance standards such as International Standards Organization (ISO) 9001 or 9002 when defining basic quality systems. Advanced Quality Systems build upon these basic standards by adding additional product or industry-specific requirements along with requiring the implementation of appropriate advanced engineering and manufacturing quality management practices (e.g., Quality Function Deployment (QFD), or Statistical Process Control (SPC).

D1 9000 (Boeing)

Boeing uses the appropriate elements of ISO 9000 along with early identification of key product and process characteristics. The key characteristics form the major area of concentration for monitoring, controlling, and variability reduction.

Six Sigma (Motorola)

Six Sigma is a process for identifying opportunities for improvement of business and product processes. The process includes a sequence of steps that leads to the identification of opportunities for improvement by first baselining the process capability in errors or defects in parts per million (ppm). The goal of Six Sigma for these processes is 3.4 ppm or fewer defects.

AS 9000 (Aerospace Industry)

AS 9000 cites all elements of ISO 9000 and reinforces these standards with additional specificity for the aerospace industry. These additions are based on FAA regulatory requirements and aerospace industry advanced engineering and manufacturing quality practices.

QS 9000 (Automotive Industry)

Similar to AS 9000, the automotive industry quality standard embraces all elements of ISO 9000 and builds on them. This standard is very prescriptive and mandates specific activities during all product/process phases (e.g., early quality planning, Quality Function Deployment (QFD) in the design phase, and use of Statistical Process Control (SPC)).

Quality Function Deployment (QFD)

Quality Function Deployment (QFD) is a systematic process for truly understanding the user's requirements and expectations and documenting the best approach and methods for satisfying those requirements. The QFD process revolves around understanding what the customer really expects and focuses efforts on satisfying those needs through extensive tradeoff analyses. QFD also provides a way of tracking and tracing tradeoffs through various levels, from requirements through design decisions to production and support processes.

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What Is ISO 9000?

Many contractors are adopting and being certified under ISO 9000. ISO 9000 is a series of international quality assurance system standards. The elements comprising ISO 9000 are similar in intent to the now-cancelled MIL-Q-9858A. ISO 9001 has the broadest scope of the ISO 9000 series.

Philosophical Structure of ISO 9001
Quality System Requirements

1. Management responsibility
2. Quality system
3. Contract review
4. Design control
5. Document and data control
6. Purchasing
7. Control of customer-supplied product
8. Production identification and traceability
9. Process control
10. Inspection and testing
11. Control of inspection, measuring, and test equipment
12. Inspection and test status
13. Control of nonconforming product
14. Corrective and preventive action
15. Handling, storage, packaging, preservation, and delivery
16. Control of quality records

17. Internal quality audits
18. Training
19. Servicing
20. Statistical techniques

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How Is Statistical Process Control Used?

Manufacturing personnel use Statistical Process Control (SPC) extensively to prevent nonconforming material.

SPC is a method for assessing if the process is changing and determining if the manufacturing process is predictable.

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What Does SPC Provide Decision Makers?

SPC consists of a set of statistical tools that provide feedback about the abilities and limitations of a process. These tools should be applied to key/critical processes. SPC presents the decision maker with relevant facts and, in many cases, provides an estimate of the probability of making a wrong or right decision.

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What Can Cause Production Problems?

During the production process, various problems may arise that will adversely affect the acquisition process. There are five major causes of these production problems:

- Unstable Rates and Quantities
- Design Instability
- Undue Emphasis on Schedule
- Inadequate Configuration Management System
- Inattention to Environmental Impact

It is important to understand these "warning flags" so that an IPT can be sensitive to the impact of such factors. IPT members should recognize and assess the effect these factors have on cost, schedule, and performance.

Unstable Rates and Quantities

Any time the rate of manufacturing and/or the overall quantity to be manufactured changes, production efficiency can suffer, leading to increased cost. An effective production line is designed to produce at a cost-effective rate and quantity. Increases and decreases to the projected rate and quantity can result in under- (too little) or over- (too much) production capacity. Both situations can result in cost increase to the program.

Design Instability

When the design changes, the 5Ms often change, and the manufacturing planning is reset to zero. This impact is particularly significant during the fabrication of parts. It takes time to redevelop and/or replan for production when the design is changed. Often there is not enough time or money to address the impacts of a design change adequately. Design instability during production may result from the design effort not being completed or from changes in the user requirements.

Undue Emphasis on Schedule

Holding firm to a contractual schedule or an initial operational capability (IOC) date when there is excessively high or unknown manufacturing risk is asking for trouble. In the past, customers (combat commanders) wanted their systems so badly that they let time be the sole driver. This emphasis produced poor-quality systems.

Sometimes there is no chance of making schedule because the development of the production processes required some technological breakthrough. Schedule delays are common when the manufacturing solutions require new materials, methods, machines, manpower, and measurement systems. The process needs to be event driven with entry/exit criteria, and not driven solely by schedule or the IOC.

Inadequate Configuration Management System

A corollary to design instability is not knowing which design to produce. Inadequate configuration management can be as devastating as design changes themselves. If the wrong design is executed in manufacturing, it just creates more work trying to correct the problem. Good configuration management goes hand-in-hand with good design control.

Inattention to Environmental Impact

Given the environmental laws and their continued complexity, programs could be faced with both prime contractors and suppliers being shut down or having heavy fines levied for violating environmental laws. In some States, stringent environmental policies are causing companies to move out of the State or shut down all together. Throughout the acquisition process, program management needs to be aware of the changing environmental laws. Where possible, take design and process actions to eliminate environmental hazards.

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